26748 PDF

MOTHPROOFING AND THE ENVIRONMENT

T. Shaw and D. Allanach,
IWS Development Centre,
Ilkley, W. Yorks LS29 8PB.

Monograph

SYNOPSIS

The future of mothproofing in UK is threatened by new regulations, issued to Regional Water Authorities by the Department of the Environment, which will severely restrict industrial discharges of mothproofing agents from 1 January 1993. Additionally, several mothproofing agents have recently been withdrawn and the reduced variety of agents now available will impair the industry's ability to comply with the new regulations.

This paper reviews in detail the effects of these changes on the carpet and carpet yarn manufacturing industry in Kidderminster and West Yorkshire, the regions where the industry is most highly concentrated. Strategies are proposed for optimising the use of existing mothproofing technology to avoid conflict with the new regulations, as far as this is possible. Finally, the form which new, non-polluting mothproofing technology might take is suggested and progress with the development of such technology is reviewed.

MOTHPROOFING AND THE ENVIRONMENT

T. Shaw and D. Allanach,
IWS Development Centre,
Ilkley, W. Yorks LS29 8PB.

INTRODUCTION

Proofing of wool and wool blends against insect attack has been regarded as an essential part of the carpet manufacturing process for many years, certainly since cheap and easily-applicable mothproofing agents first became available in the late 1950s. UK is the world's largest producer of wool and wool blend carpets and carpet yarns by a considerable margin; this sector of the industry consumes about 45 million kg of fibre, and is also the major user of mothproofing agents.

During the last year, two important changes have taken place which will influence - or even threaten - the future of mothproofing in UK. The first was the recent announcement by the Department of the Environment that the pollution of surface waters, caused by industrial discharges of mothproofing agents, will be strictly regulated from 1 January 1993. The second is the reduction in the variety of mothproofing agent types available to the textile industry, following the enforced withdrawal by chemical manufacturers of several agents during the past year. Both these changes will make mothproofing more difficult. At best, the industry will no longer be able to choose the mothproofing agents it uses freely, according to the normal criteria of effectiveness, convenience of application and cost. At worst, mothproofing by presently used processes may have to be discontinued in certain areas of UK, where the concentration of mothproofing activity is greatest. In these cases, the development and transfer to industry of new mothproofing technology is essential and urgent.

REGULATION OF MOTHPROOFING AGENT DISCHARGES IN UK

On 30 April 1989, the UK Department of the Environment issued Circular No. 7/89, entitled "Water and the Environment". This document is intended to provide guidelines for Water Authorities and their successors on "the implementation of European Community Directives on pollution caused by certain dangerous substances discharged into the aquatic environment". Mothproofing agents are included among these "dangerous substances", and discharges of mothproofing agents will be regulated nationally in UK for the first time from January 1993.

Although the DoE guidelines on the control of pollution caused by mothproofing agents are issued under EEC legislation, it must be emphasised that they are operative in UK only. The only other EEC member state that is even considering regulating mothproofing agent discharges at the present time is the Netherlands, where consultation is as yet at an early stage.

Control of pollution of the aqueous environment in UK is achieved through a system of environmental quality standards (EQS's). In effect, these are maximum concentrations of hazardous substances allowed in surface waters. The list of EQS values for mothproofing agents, effective from 1993, is reproduced in Table I. The EQS figures are given in terms of mothproofing agent active ingredients and are listed alongside the names of the active ingredients and the mothproofing formulations which contain them. The allowed concentrations vary widely from 1 ng/L for cyfluthrin, the active ingredient of Eulan SP (Bayer), to 25000 ng/L for sulcofuron (Mitin FF, Ciba-Geigy). This reflects the differing toxicity of the active ingredients to aquatic organisms.

Figure 1 shows the route by which mothproofing agents discharged by the textile industry enter surface waters. Almost all mill effluent in UK is discharged through municipal sewage treatment works (STW), which remove mothproofing agents to varying degrees; the sewage treatment works effluent is then discharged to the receiving water, usually a river, where it is diluted according to its volume relative to river flow. It is the responsibility of Regional Water Authorities to ensure that industrial discharges do not result in the concentration of hazardous substances in the receiving water rising above the EQS. The Water Authorities achieve this by regulating trade effluents through consents to discharge. These consents regulate both the volume of the discharges and the concentration of hazardous substances which they may contain.

Figure 2 shows how the Water Authority calculates trade effluent consent limits. Starting with the EQS value, it is possible to calculate an acceptable mass of a hazardous substance which may be discharged from the STW to the river, based on known flow rates through the STW and in the river. The river flow rates used in these calculations are rates at low river flow, chosen to ensure that the EQS is complied with for 95% of the time. If the rate of removal of the hazardous substance in the STW is known (and this usually is the case for established mothproofing agents), an acceptable mass of substance which may be allowed to enter the sewage treatment works can then be calculated. The next step is to total the consented discharge volumes of all the dischargers in the catchment area of the sewage treatment works who have a consent to discharge the hazardous substance in question. By simple division of the acceptable mass of hazardous substance by the total volume of the discharges which are consented to contain it, the maximum concentration of the effluent may then be calculated.

This method of calculation assumes that all trade effluent consent limits are used - and used to the maximum - by all those to whom they are issued. Because this is seldom the case, it leads to situations where the consent limits issued are more stringent than required to meet the EQS in practice. This point will be discussed in more detail later.

AVAILABILITY OF MOTHPROOFING AGENTS

During the last year, important changes have taken place in the variety of mothproofing agents available to the UK textile industry. Figure 3 summarises the situation.

Sulcofuron or Mitin FF (Ciba-Geigy), the oldest mothproofing agent on the market, remains available but it has its limitations for use in the carpet industry. First, it is ineffective against brown house moth, which is probably the most important pest of wool textiles in moist, temperate climates such as UK. Second, Mitin FF is unsuitable for application during the blend dyeing of wool/nylon, which constitutes the major part of wool-containing carpet production in UK. This is because Mitin FF partitions in favour of the nylon, leaving the wool component of the blend virtually untreated. Mitin FF can however be applied to wool/-nylon blends in an after-treatment at 60°C although even then, it is advisable to apply higher levels than would be required for 100% wool. Third, Mitin FF is unsuitable for use in continuous scouring applications at relatively low temperatures (40°C) because it has insufficient affinity for the fibre in these conditions. Last, Mitin FF is more expensive than competitive products.

Production of chlorphenylid, the active ingredient of Eulan U33/WA New (Bayer) and one component of Mitin LP (Ciba-Geigy), ceased in July 1988 because of Federal German regulations forbidding processes which generate dioxins or dibenzylfurans, even as impurities which are removed from the final product before sale (as was the case with chlorphenylid manufacture). Chlorphenylid was one of the most widely used mothproofing agent active ingredients and had been for many years. The effects of the withdrawal of chlorphenylid are now beginning to be felt by the industry as stocks of the product become exhausted.

Flucofuron, the second active ingredient of Mitin LP, had been marketed previously as the sole active ingredient of Mitin N paste. It has recently been reintroduced as Mitin N liquid (Ciba-Geigy), a more convenient form of the product. At present, industrial experience with this new formulation is limited and many factors concerning its performance will only become clear as industrial usage becomes more widespread. Like sulcofuron and chlorphenylid, flucofuron is not effective against brown house moth.

The pyrethroids, permethrin and cyfluthrin, are the most widely used mothproofing agents in the UK today. From the industry's point of view, they have several advantages over other mothproofing agents, including effectiveness against brown house moth, equal partitioning between wool and nylon in blend dyeing, and the ability to be applied in continuous scouring processes as well as in the dyebath. Cyfluthrin (Eulan SP, Bayer) has now been withdrawn in all countries outside UK because of reports of irritancy to textile industry operatives. It is not known how long supplies to UK industry will continue.

Were it not for environmental considerations, there is little doubt that pyrethroid-based mothproofing agents would take over almost the whole of the UK market, and permethrin would replace cyfluthrin if the latter were to be withdrawn. However, this would greatly increase pyrethroid discharges by the industry and, as will be shown later, there is a pressing need to reduce these discharges to comply with the DoE guidelines which will come into effect in 1993.

EFFECTS ON THE INDUSTRY

Introduction

In UK, mothproofing is very largely a carpet industry technology, and the carpet industry is highly concentrated in a few geographical areas, the most important being Kidderminster, West Yorkshire and Kilmarnock. (See Figure 4.) About 13 million kg of fibre is mothproofed in Kidderminster each year, 24 million kg in West Yorkshire and 5 million kg in Kilmarnock. This concentration of industry, in combination with the EQS system used for control of pollution in UK, has the effect of increasing the stringency of trade effluent consent limits, particularly in cases where the river into which mothproofing agents are ultimately discharged is small in volume.

By conducting surveys of the mothproofing activities and practices of the industry in these areas of high concentration, it is possible to calculate the likely effects of changes in the regulations governing mothproofing agent discharges and the reduced variety of mothproofing agents now available. It is also possible to plan for the future by advising on the optimum pattern of mothproofing agent usage for compliance with the forthcoming regulations - or where compliance is not possible using present technologies, to advise on the installation of new mothproofing processes, which hopefully will be available in time. One thing is inevitable: mothproofing will be more expensive in future and this may result from increased chemical costs, increased capital costs (for the machinery required for new application technologies), increased labour costs, or a combination of all three.

IWS has conducted industry surveys in Kidderminster in 1988 and in West Yorkshire in 1989, and aims to survey the Kilmarnock industry in the near future. The next sections of this paper show the results of the Kidderminster and West Yorkshire surveys and the conclusions drawn from them.

Kidderminster

Figure 5 shows the pattern of mothproofing agent usage and discharge by the Kidderminster carpet industry in 1988. The majority of the mothproofing in the town is carried out in the dyebath and the exhaustion rates shown are actual average rates across the industry, calculated from analyses of mill effluents carried out by the Severn Trent Water Authority (STWA). Removal rates in the sewage treatment works are also actual values, again calculated from figures supplied by STWA. It can readily be seen that mothproofing agent concentrations in the River Stour in 1988 were well above those called for in the DoE guidelines from 1993.

What then should the Kidderminster carpet manufacturing industry do to try to comply with future EQS requirements, taking into account the reduced availability of mothproofing agents in future? The following is suggested as the best possible way forward, using presently available mothproofing agent application methods.

1. Use sulcofuron (Mitin FF) as far as possible. This mothproofing agent has low toxicity to aquatic life and a correspondingly generous EQS value.

2. Use flucofuron (Mitin N liquid) to the limit of the EQS value.

3. Use permethrin (and cyfluthrin if it remains available) for the remainder of the production total.

In the following calculations, water usage in Kidderminster is assumed to be 55 litres per kg of fibre mothproofed, the actual overall average for the town.

The results of implementing the strategy set out above are shown in Figure 6A. In this first case to be considered, mothproofing with Mitin FF is restricted to the production of 100% wool yarns, and separate stock dyeing of wool and nylon for later blending, which form only 5% of the town's total mothproofed output. Flucofuron can only be used on 1.7 million kg of yarn before the EQS in the River Stour is reached. This leaves 10.8 million kg of yarn to be treated with pyrethroids. If cyfluthrin is withdrawn and permethrin is used, then this will result in the EQS for permethrin being exceeded by a factor of 13. If cyfluthrin remains available, this will not be very helpful, because only a further 0.3 million kg of yarn could be treated before the EQS would be exceeded.

Figure 6B shows a second alternative, in which Mitin FF is used to the limit of the EQS, by applying the mothproofing agent to wool/nylon blends in a low temperature treatment following dyeing. To carry out this process, the dyebath temperature is reduced to about 60°C, the mothproofing agent is added, and the bath is run for about 15-30 min. This procedure improves the wool-nylon partition of Mitin FF, though to ensure adequate proofing it is still advisable to apply more mothproofing agent than would be used for 100% wool. Assuming an application rate 50% greater than used for 100% wool, and the same (90%) exhaustion rate, this would mean that a total of 6.7 million kg of wool/nylon blend per year could be treated, in addition to the 0.7 million kg of 100% wool listed in figure 6A, giving a total of 7.4 million kg of fibre mothproofed with Mitin FF. As in the previous scenario, 1.7 million kg could be treated with Mitin N (flucofuron), leaving 4.2 million kg to be treated with permethrin. This would result in a concentration of permethrin of 51 ng/L in the River Stour in low flow conditions - still 5 times over the EQS. Clearly, the situation in Kidderminster is hopeless unless new mothproofing technologies become available.

Figure 7 shows the calculation of future trade effluent consent limits according to the scheme outlined in Figure 2. Only sulcofuron, flucofuron and permethrin are considered because these may be the only mothproofing agent active ingredients available in 1993. Indications already received from STWA are that the consent limits for sulcofuron and flucofuron may be set lower than the values calculated here, because of uncertainties about their rate of removal in the sewage treatment works or their toxicity to aquatic organisms.

In Table II the concentration of mothproofing agents in the effluent of mills using one mothproofing agent for all production are compared with the calculated consent limits and the limits which STWA have indicated are likely to apply from 1993. It is clear that a mill using even the most environmentally friendly product - Mitin FF - could not use a single mothproofing agent, but would be compelled to use a mixture. This arises because of the assumption in the calculation of trade effluent consent limits that all consents are used.

West Yorkshire

The situation in West Yorkshire is somewhat more complex than in Kidderminster because of the greater use of mothproofing during continuous scouring processes, which are much more polluting than dyebath mothproofing. Information available to IWS on mothproofing in West Yorkshire is also less complete than for Kidderminster.

It should also be noted that the calculations for West Yorkshire are for the Calder catchment as a whole, and the calculated concentrations of mothproofing agents in the river are those present as the river leaves the area in which mothproofing is carried out. There is a need for further, more detailed calculations, which reflect the multiplicity of sewage treatment works receiving mothproofing agents and discharging into the Calder and its tributaries. (By contrast, all mothproofing agent discharges in the Kidderminster area pass through a single sewage treatment works.)

The present situation in West Yorkshire is summarised as accurately as available data will allow in figure 8. Here again, it can be seen that present practices cause EQS values for all mothproofing agents in the River Calder to be exceeded, though not by such large factors as in the River Stour below Kidderminster. This is simply a reflection of the relationship between the level of mothproofing activity in the two areas and the volume of water in the respective rivers in low flow conditions. Figure 8 also shows that about half of the mothproofing agent pollution in West Yorkshire arises from mothproofing during scouring, although three times as much fibre is mothproofed in the dyebath.

What strategy should the West Yorkshire industry follow to minimise mothproofing agent discharges? The following is suggested.

1. Eliminate mothproofing agent discharges from treatment during scouring. The feasibility of this is discussed later.

2. Select mothproofing agents for dyebath mothproofing on the following basis:

As first choice, use permethrin to the limit of the EQS. Permethrin is active against brown house moth and partitions equally in wool/nylon blend dyeing.

As second choice, use flucofuron (Mitin LP) to the limit of the EQS. Flucofuron is applicable to wool/nylon blends, but is not active against brown house moth.

Use sulcofuron for any remaining production, with the proviso that this must be 100% wool or a low temperature after-treatment process must be used on wool/nylon blends.

Figure 9 shows the result of implementing these strategies. There is a possibility that, overall, the 1993 EQS values can be met in the Calder catchment, although it should be noted that infringements might occur in tributaries, depending on geographical situation.

The trade effluent consent limits required to ensure compliance with the EQS for the catchment as a whole are calculated in figure 10 and compared with calculated discharge concentrations from mills using single mothproofing agents for all production in Table III. Here again, it is emphasised that more stringent consent limits may be necessary on some tributaries of the Calder. The actual average rate of water usage in West Yorkshire mills is unknown, but is assumed here to be the same as Kidderminster, namely 55 litres per kg of fibre mothproofed. The few cases for which water consumption figures are available to IWS indicate that this value is not unreasonable. On the assumption that discharge of mothproofing agents from treatment during scouring can be eliminated, although water is still used to process this fibre and will dilute discharges from dyebath mothproofing, the notional rate of water usage can be increased to 83 litres per kg of fibre mothproofed in the dyebath.

Except for mills using Mitin FF (sulcofuron), the use of one mothproofing agent for all production will not be possible. Processors will each have to take note of the criteria set out above in their choice of mothproofing agents. This will not require great acts of selflessness or care for the welfare of competitors on the part of mill management, but will be made necessary by the water authority's enforcement of the consent limits.

NON-POLLUTING MOTHPROOFING TECHNOLOGIES

Introduction

The above considerations clearly indicate an urgent need for new, non-polluting mothproofing technologies. In Kidderminster, it will not be possible to mothproof all production unless new technology becomes available; even in West Yorkshire, the strategies proposed are clumsy and greatly restrict the industry's free choice of mothproofing agent. It is also of considerable concern that only a small fraction of UK carpet production in future would be protected against damage by the brown house moth, which was responsible for a spate of damage complaints in the late 1970s, before pyrethroid mothproofing agents became available.

The possibilities for pollution-free mothproofing can be divided into the three categories listed below. All these possibilities are being examined by IWS, by CSIRO in Australia or by WRONZ in New Zealand.

1. New application methods, producing zero effluent or incorporating economical effluent pre-treatment before discharge to sewer.

2. New mothproofing agents with improved ecotoxicological profile, applicable by existing technologies.

3. Entirely new principles of mothproofing, avoiding the use of pesticides.

The only one of these possibilities which may be available by 1993 is the first. This is the main thrust of IWS activities, which will be described in the remainder of this paper.

Effluent Pre-Treatment

The pre-treatment of all mothproofing effluent before discharge to sewer is technically feasible. Many methods are available, ranging from simple flocculation processes to total evaporation and incineration. These methods vary greatly in their cost and in their effectiveness. It is our view, however, that total treatment of carpet industry wet processing effluent is economically impracticable, given the large production volumes and correspondingly large water usage of the industry. A better strategy is to select the most concentrated effluents, with the lowest volumes, and treat these effluents only. In the West Yorkshire industry, where mothproofing during continuous scouring processes is widely practised, the effluent from the mothproofing bowl of the scouring set is an obvious candidate for pre-treatment.

When normal carpet yarn scouring practices are used, the volume of effluent from the last bowl of the scouring set amounts to about 1 litre per kilogram of wool treated. This contrasts with the effluent volume from yarn dyeing, for example, which might be as much as 50 litres per kg. Effluent from yarn scouring is already treated in one West Yorkshire dyehouse, using a simple flocculation system, built in-house largely from second-hand dye vats. This simple system, illustrated in figure 11, removes more than 99.9% of the mothproofing agent present in the tape scour effluent and has very low chemical and labour costs. Disposing of the mothproofing agent floc has become progressively more difficult and more expensive, however. Initially, "safe dumping" was possible, but now incineration is necessary. Alternative means of disposal must now be considered. As an example, pyrethroid mothproofing agents can be destroyed by hydrolysis with caustic soda, giving hydrolysis products which are of relatively low toxicity to aquatic organisms, and probably acceptable to water authorities.

Mini-Bowl Mothproofing of Yarns Normally Treated during Scouring

A refinement of the above procedure is to reduce the volume of mothproofing agent-contaminated effluent from the scouring line even further, to the extent where it can be disposed of directly - without the need for pre-flocculation - by safe-dumping, incineration or hydrolysis. This method uses a so-called mini mothproofing bowl, added to the end of the tape scour. The extra bowl is totally isolated from the scour, so that mothproofing agent is not carried back to the scouring and rinse bowls on the tapes. Its volume may be as little as 100-200 litres, compared with the usual 1500-2000 litres of a conventional tape-scour bowl. Because the yarn is better rinsed before it enters the mini-bowl than when it enters the fourth bowl of a conventional scour, and because turnover of liquor in the mini-bowl is very rapid, the mini-bowl seldom has to be dropped because of accumulation of contaminants. By these means, the volume of effluent from mothproofing can be reduced to a small fraction of a litre per kg of wool treated.

The mini-bowl concept requires much more sophisticated and reliable metering equipment for the dosing of mothproofing agent than that which has been used for traditional tape scour mothproofing. This is because the mini-bowl has very little "buffering capacity". With a conventional scour bowl of almost 2000 litres capacity, it is quite possible to produce satisfactorily mothproofed wool even if the supply of mothproofing agent to the bowl is disrupted for 10-15 minutes. This is because the bowl acts as a reservoir of mothproofing agent sufficient to proof several hundred kilograms of wool before it is exhausted. Clearly, this is not the case for the mini-bowl, with its low volume and rapid liquor turnover.

Figure 12 is a schematic representation showing the essential features of a mini-bowl mothproofing machine, suitable for installation at the end of a yarn scouring set. One mill in UK uses similar machinery already, and an advanced prototype embodying further developments has recently been installed in a second mill.

Mini-Bowl Mothproofing of Yarns Normally Treated during Dyeing

In Kidderminster and perhaps also in West Yorkshire, it will be necessary to find alternative methods for mothproofing yarns which would normally be treated during dyeing. This is a more difficult proposition, and probably will also prove to be more expensive.

One possible method, as yet untried, is to use the double mini-bowl arrangement, shown schematically in figure 13, to treat yarn hanks after dyeing. The first bowl contains hot water only, at the same temperature as the mothproofing bowl. The purpose of this bowl is to pre-heat and equilibrate the hanks before mothproofing, and also to rinse loose dyestuff from the yarn. The mothproofing bowl is identical with that already described. In order to defray the extra labour costs involved in mothproofing in this manner, the possibility should be considered of running the double mini-bowl at high temperature (at least 60°C), which theoretically will enable mechanical water removal in the mangle down to 40 or 45%. If this proves to be practically feasible, it will be possible to dispense with the need for centrifuging the yarn before evaporative drying.

The potential problems associated with a process such as this should not be under-estimated. Bleeding of dyestuff into the bowls and unpredictable shade changes are just two of the possibilities which will have to be faced, and it will be necessary to proceed cautiously at first, and perhaps to make some changes in dyestuff selection in order to avoid spoilage of yarn due to these and other problems.

Other Possibilities for Pollution Abatement

Several other possibilities are being considered for reducing the levels of mothproofing agents in carpet mill effluent. It is too early to discuss these possibilities in detail here because they are the subject of patent activity. However, they can be mentioned in outline.

The first is another machinery development, which may prove to be a useful alternative to the mini-bowl concept for mothproofing yarns or loose stock. The second is a dyebath pre-treatment which has the potential to increase the exhaustion of pyrethroid mothproofing agents from 92-94% to more than 99%. The third is a possible method for treating carpet during the backing process, which will give a durable effect without the need for the prolonged steaming required to fix conventionally formulated mothproofing agents applied at this stage of manufacture.

New Mothproofing Agents

Both IWS and CSIRO are evaluating new pesticides in the hope of finding suitable candidates for future mothproofing agents. The quantitative examination of the effluent problem described in earlier sections of this paper shows that only relatively modest increases in dyebath exhaustion rate, rate of removal in sewage treatment and decreases in toxicity to aquatic organisms are required in a mothproofing agent which will satisfy the requirements of the forthcoming UK regulations. However, the amount of work which must go into ecotoxicological testing and evaluation of the effectiveness of a candidate mothproofing agent means that there is no possibility that such a development could be available before 1993.

New Principles of Mothproofing

Mothproofing processes employing new principles and avoiding the use of pesticidal substances are further away than the possibility of new mothproofing agents which use pesticides. At present, it is too early even to discuss the principles which are being examined.

Good Housekeeping

Finally, it is worth mentioning the effects of good housekeeping on pollution abatement. This is possibly best illustrated by consideration of figures 7 and 10, which show that the EQS values in the River Stour and the River Calder are reached when the industry releases 30 g or 173 g of permethrin per day. This equates to 300 ml or 1730 ml of the 10% active formulation, and spillages of this magnitude during the day can easily be imagined. It is recommended, therefore, that drums of mothproofing agent in use are stored over trays of sufficient volume to catch all spillages, and that neither these spillages nor drums or other containers used for mothproofing agents are rinsed down the drain. Finally, all procedures should be examined for the possibility of accidental release of mothproofing agent to drain. One common example of this comes from overflow of dyebaths, through splashing or steam condensation, during the early stages of dyeing, before exhaustion of mothproofing agent onto the load has taken place. Undoubtedly, there is much that can be done to reduce mothproofing agent discharges occurring through spillage or wastage.

CONCLUSIONS

New regulations governing the discharge of mothproofing agents in effluents, in combination with a reduced selection of mothproofing agents available from chemical manufacturers, will severely restrict the ability of carpet and carpet manufacturers to mothproof their products, especially in areas where the industry is highly concentrated.

In Kidderminster, new mothproofing technologies will be necessary in order that some form of mothproofing treatment can be applied to all production. In West Yorkshire, the choice of mothproofing agent will be restricted by environmental considerations, and the industry in this area may also prefer to install new technology in order to preserve freedom of choice, albeit at greater expense. It is considered especially important to continue to protect as large a proportion of UK carpet production as possible against the brown house moth by mothproofing with pyrethroids.

Many new technologies are in development to ensure the future of mothproofing in UK. These are aimed at providing solutions to the problem suitable for application in the short, medium and long term. All of these solutions are likely to be more costly and less convenient than presently used methods. It is considered that the only possibility of a short-term solution, which will be available before the new regulations come into effect in 1993, is to develop alternative, non-polluting methods of applying existing mothproofing agents.

TABLE I

DoE Circular 7/89

"Water and the Environment"

The implementation of European Community Directives on pollution caused by certain dangerous substances discharged into the aquatic environment

Active ingredient	Mothproofing agents	EQS nanograms/litre active ingredient
Chlorphenylid	Eulan WA New	50
Cyfluthrin	Eulan SP	1
Sulcofuron	Mitin FF h.c.	25000
Flucofuron	Mitin N	1000
Permethrin	Eulan SPN Eulan WP Mitin BC Perigen SMA-V	10

TABLE II

Kidderminster

CALCULATION OF MOTHPROOFING AGENT DISCHARGES AND COMPARISON WITH FUTURE CONSENT LIMITS

	SULCO-FURON	FLUCO-FURON	PER-METHRIN
Application % active oww	0.4	0.1	0.012
Exhaustion %	90	90	92
Discharge mg/kg wool	400 (600)*	100	8.4
Concentration ug/L	7200 (10800)*	1800	153
Consent limit ug/L			
- Calculated	6000	250	9
- Probable	2000	200	9

* Values in brackets for low temperature aftertreatment of wool/nylon

TABLE III

West Yorkshire

CALCULATION OF MOTHPROOFING AGENT DISCHARGES AND COMPARISON WITH FUTURE CONSENT LIMITS

	SULCO-FURON	FLUCO-FURON	PER-METHRIN
Application % active oww	0.4	0.1	0.012
Exhaustion %	90	90	92
Discharge mg/kg wool	400	100	10
Concentration ug/L	5500	1370	137
Consent limit ug/L - Calculated	18000	750	30

Figure 1

Environmental Quality Standards

Concentration of substance which must not be exceeded in surface waters

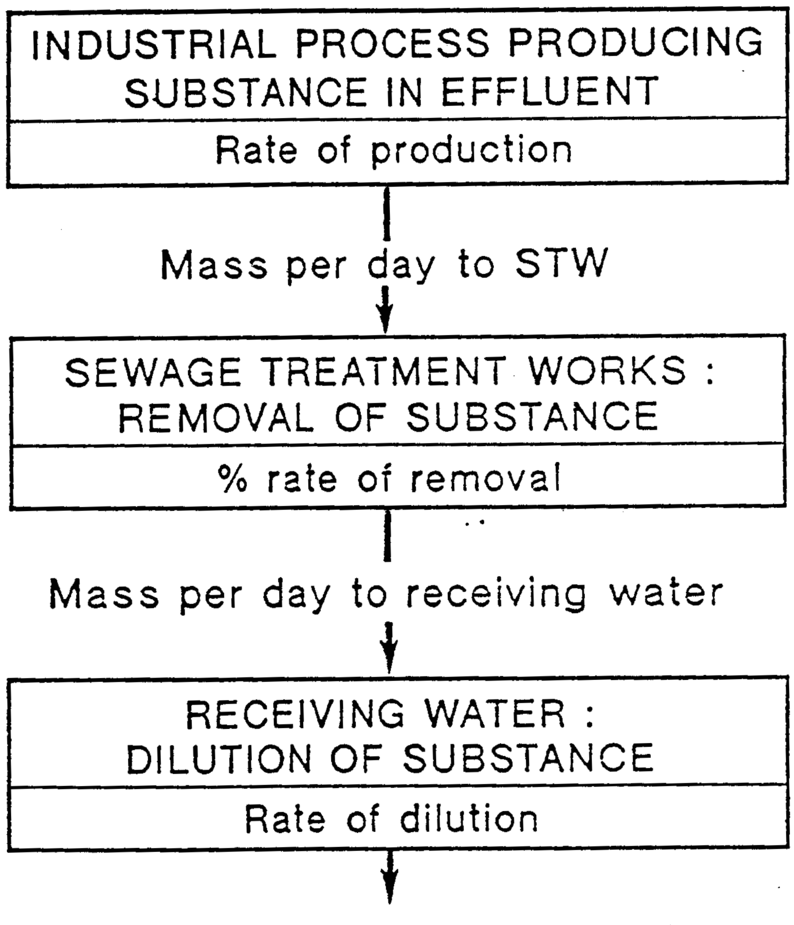


Figure 2

Trade Effluent Consent Limits

Method of calculation from EQS

INDUSTRIAL PROCESS PRODUCING SUBSTANCE IN EFFLUENT

Consented discharge concentration
Consented discharge volume

Acceptable mass per day to STW

SEWAGE TREATMENT WORKS : REMOVAL OF SUBSTANCE

% rate of removal

Acceptable mass per day to receiving water

RECEIVING WATER : DILUTION OF SUBSTANCE

Rate of dilution

Concentration in receiving water
= Environmental Quality Standard

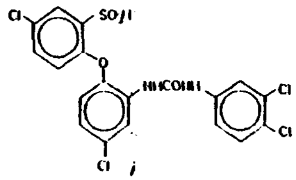
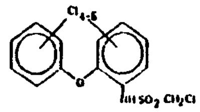
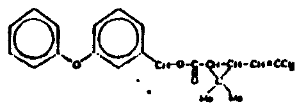
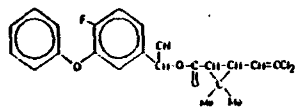
Sulcofuron		Available. Not effective against H. ps. Not applicable to wool/nylon. Expensive.
Chlorphenylid		Withdrawn 1988. Problems with toxins in intermediates.
Flucofuron		Reintroduced 1989. Not effective against H. ps.
Permethrin		Available. Effective against H. ps., but under threat.
Cyfluthrin		Withdrawn outside UK 1988. Irritancy problems.

Figure 3 : Availability of mothproofing agents in UK, 1989

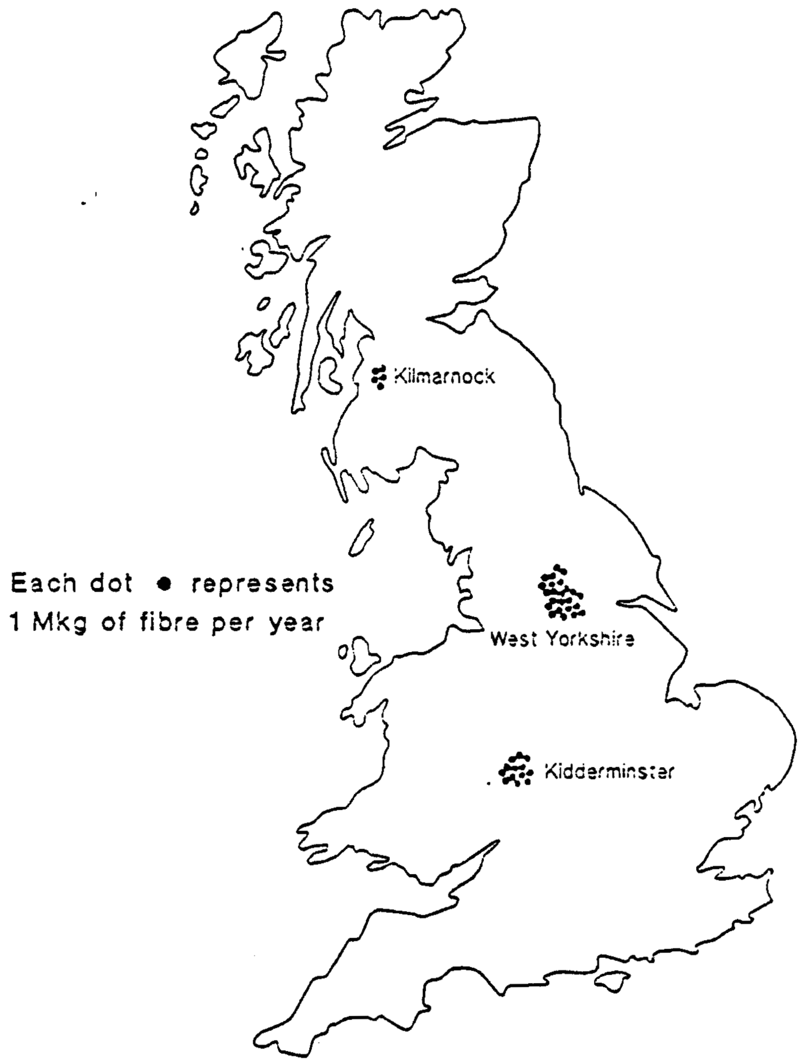


Figure 4 : Geographical distribution of mothproofing in UK, 1989

Figure 5

Kidderminster

8 major mills within a 5-mile radius mothproofing 13.3 Mkg/year

MOTHPROOFING AGENT DISCHARGES 1988

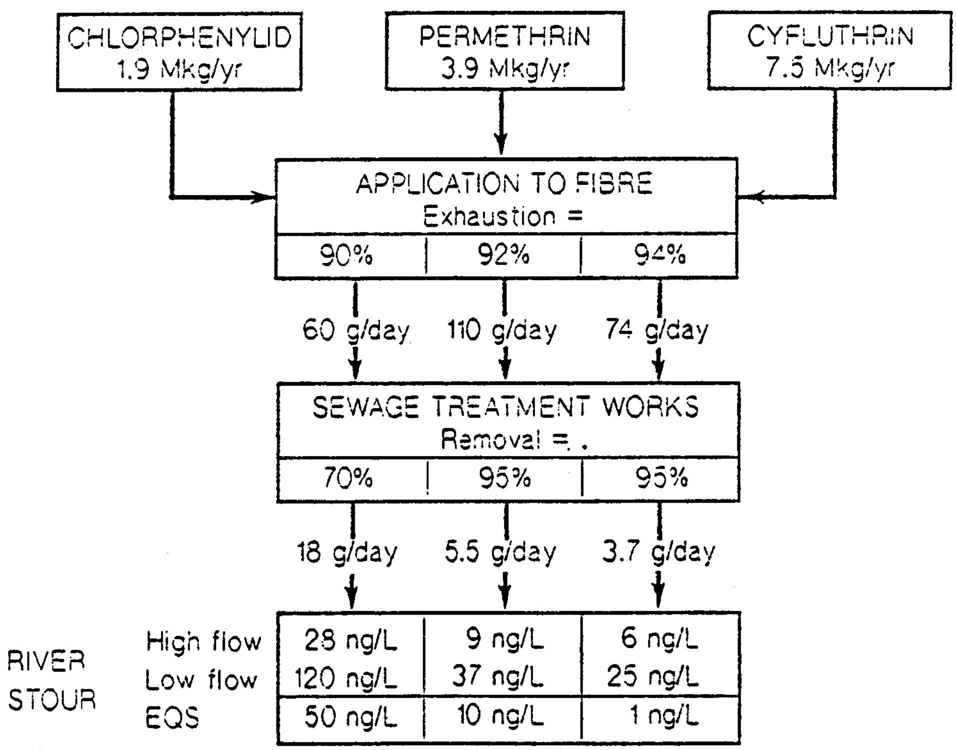


Figure 6A

Kidderminster

8 major mills within a 5-mile radius mothproofing 13.3 Mkg/year

BEST POSSIBLE FUTURE SCENARIO (A)

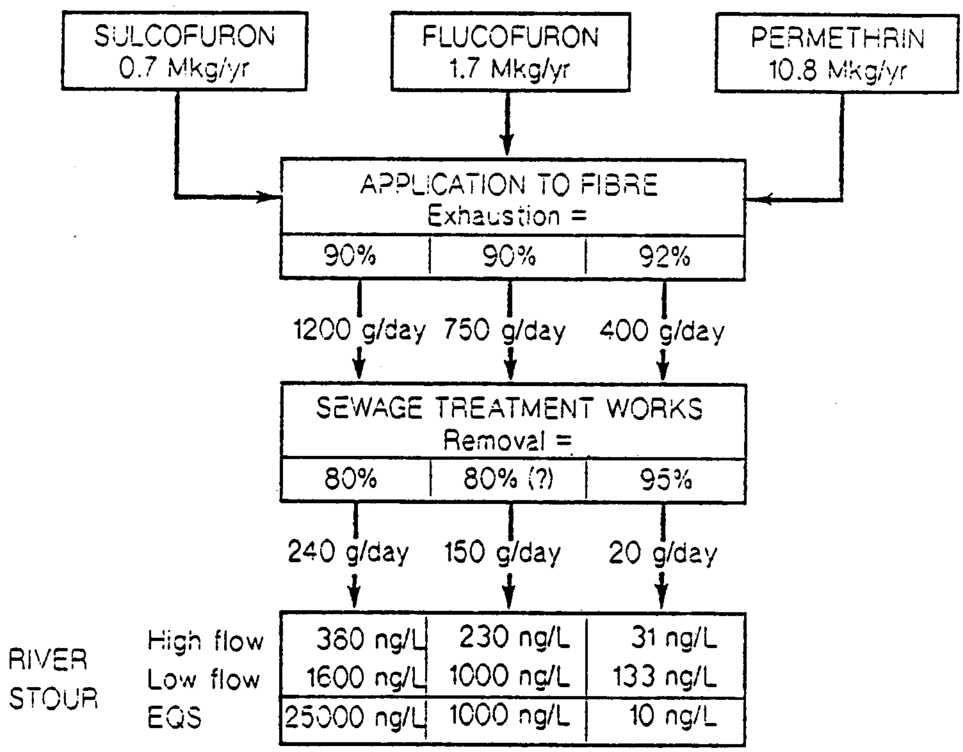


Figure 6B

Kidderminster

8 major mills within a 5-mile radius mothproofing 13.3 Mkg/year

BEST POSSIBLE FUTURE SCENARIO (B)

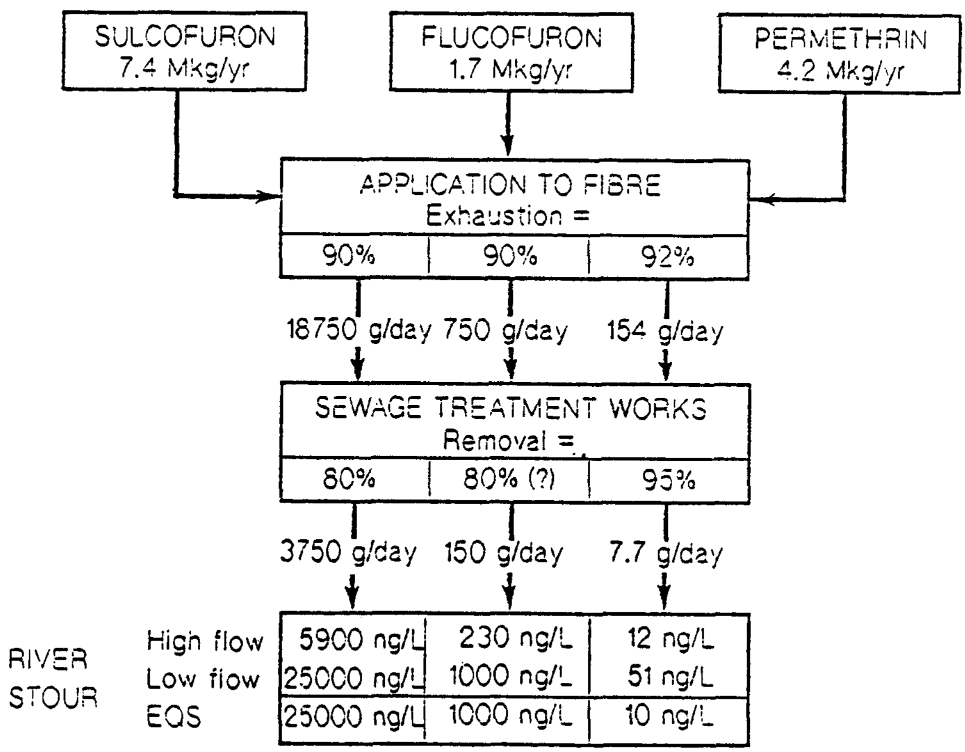
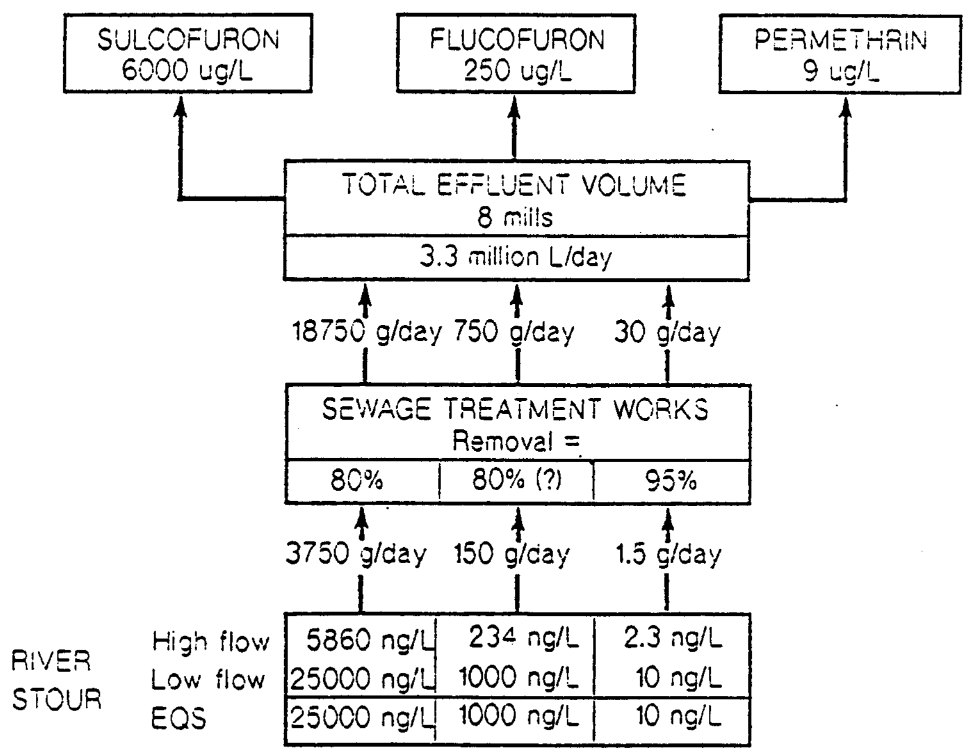


Figure 7

Kidderminster

8 major mills within a 5-mile radius mothproofing 13.3 Mkg/year

CALCULATION OF TRADE EFFLUENT CONSENT LIMITS



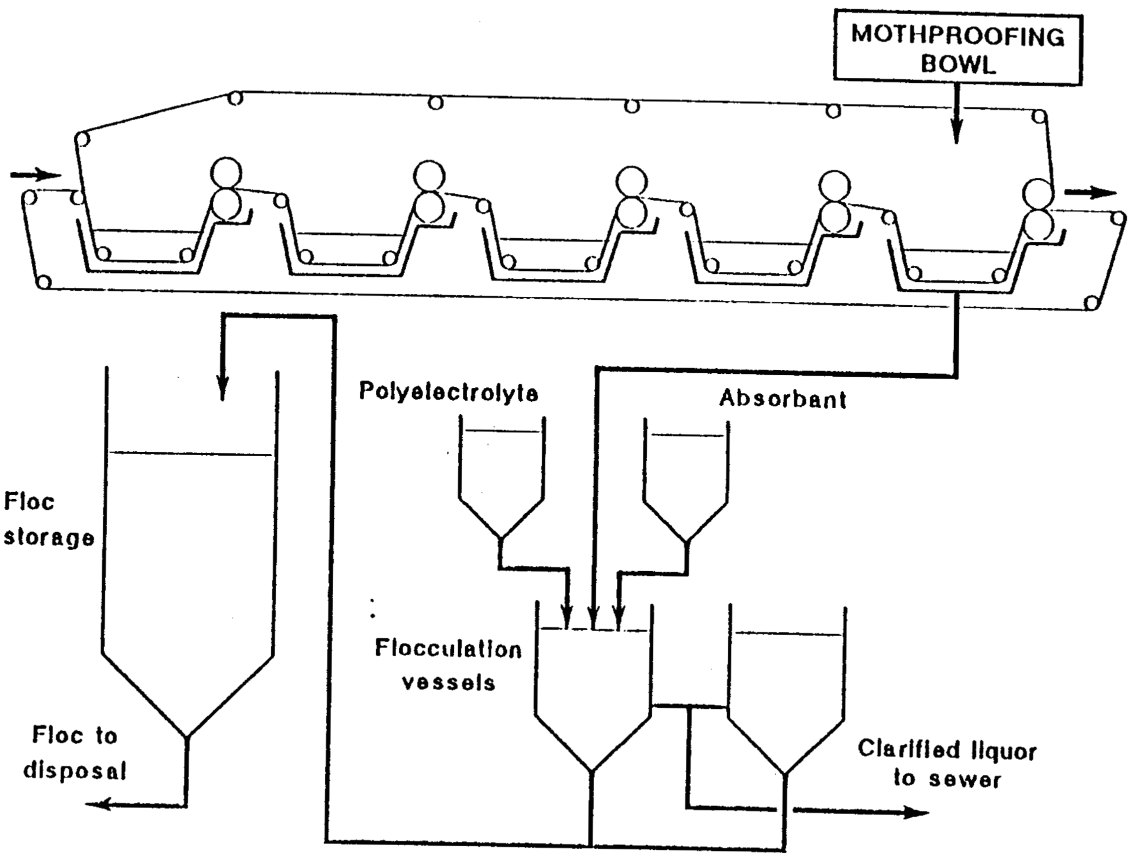


Figure 11 : Scheme for treatment of tape-scour effluent

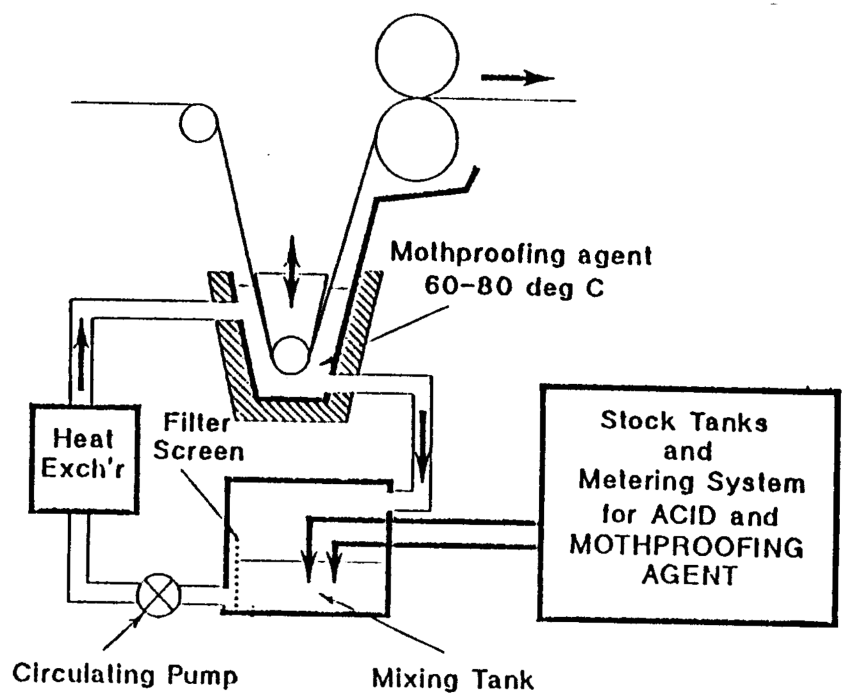


Figure 12 : Mini-bowl mothproofing machine for treatment of yarns normally treated during continuous scouring

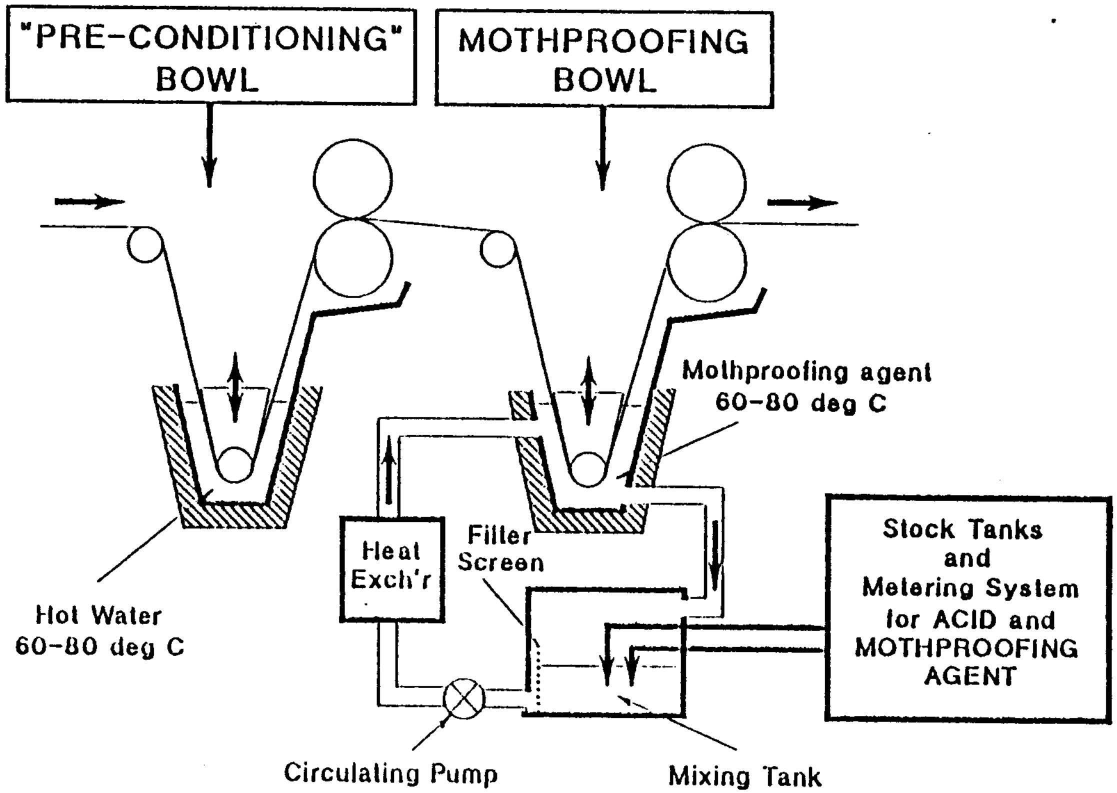


Figure 13 : Mini-bowl mothproofing machine for yarns normally treated during hank-dyeing

Figure 8

West Yorkshire (Calder Catchment Area)

About 20 mills within a 10-mile radius mothproofing 24.5 Mkg/year

MOTHPROOFING AGENT DISCHARGES 1988/89

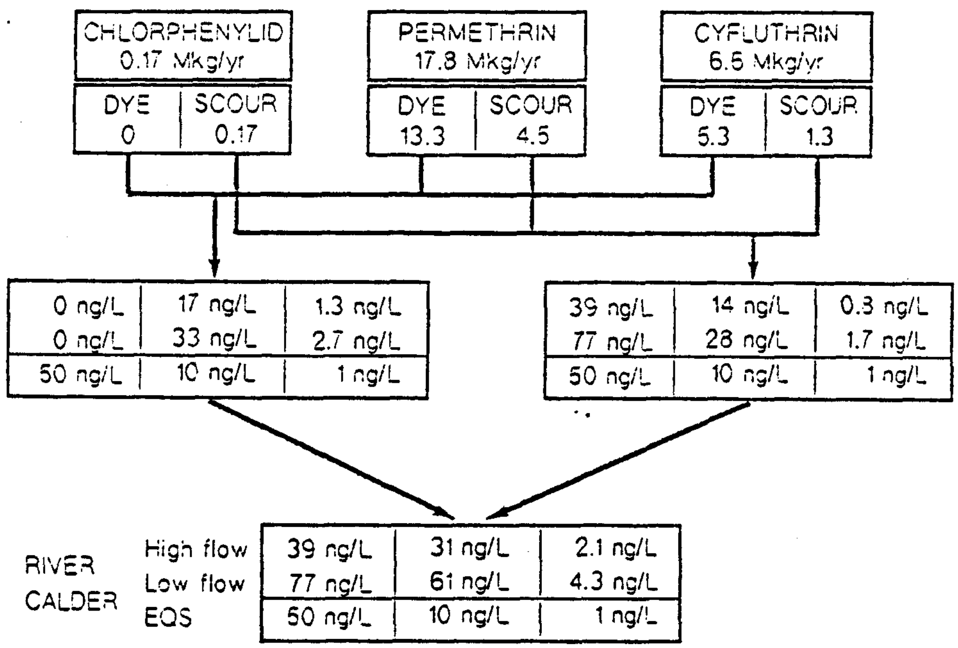


Figure 9

West Yorkshire (Calder Catchment Area)

About 20 mills within a 10-mile radius mothproofing 24.5 Mkg/year

BEST POSSIBLE FUTURE SCENARIO

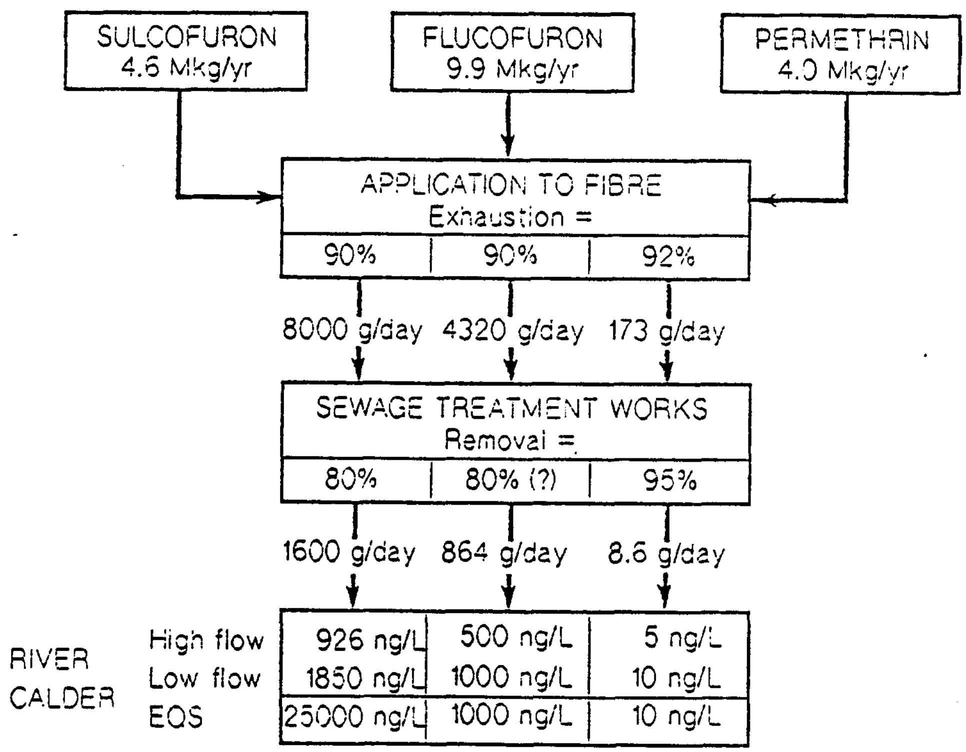


Figure 10

West Yorkshire (Calder Catchment Area)

About 20 mills within a 10-mile radius mothproofing 24.5 Mkg/year

CALCULATION OF TRADE EFFLUENT CONSENT LIMITS